



Energy Management Mistakes in Industrial and Commercial Facilities

An Online Continuing Education Course for Engineers

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Energy Management Mistakes in Industrial and Commercial Facilities

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Introduction

This course is a broad overview of facility energy management. It is intended to identify areas that may be overlooked, such as the interrelationship of projects or the importance of understanding the details. It is not intended to teach the details of various energy calculations though some general calculations are covered. It does, however, give a big picture to allow important areas not to be forgotten. Successful energy management is more about avoiding simple mistakes and recognizing the obvious. This course identifies some common mistakes and lays a foundation of points to consider whether implementing a comprehensive energy management program or completing a single project. The information may not be new for some, but the goal is to gain some new knowledge or perspective that can be applied. Take time reading the material and consider its application.

The Big Picture

Energy management begins with taking a large systems view of the entire facility being managed. Almost everything crossing the facility boundary can impact energy whether it flows through a meter, arrives by truck, or walks through the door. When an energy-saving measure is implemented, it is imperative to consider any ripple effect it may have in other areas. For example, a reduction in lighting energy will also affect space conditioning energy, or a disgruntled employee can contribute to energy waste.

After understanding that the facility operates as a system, identify the item that makes the largest impact on energy consumption and what drives it. For example, in most retail facilities space conditioning is the greatest component of energy consumption. In industrial facilities, the manufacturing process is usually the largest consumer. In distribution centers, lighting can be the major component. Identifying the largest energy user pinpoints a likely starting point for conservation efforts.

Next, to become successful in energy management, a realistic system of quantifying consumption must be developed for a facility. The typical method is dollars spent on energy. This method falls far short of accurately measuring program success. However, it is the method most preferred by the finance staff. Granted, the main objective is to drive down the cost, but the dollar amount of the energy bill often tells us very little about energy efficiency. Therefore, it is necessary to somehow normalize consumption patterns to account for the various variables. For example, in an industrial facility it may be units energy per unit produced, in a hospital it may be units energy per patient-hours, or in a retail space it may be units energy per square foot per degree day. This approach is important because it allows an answer to the question “Did our energy costs change because of some internal activity or an external impact?”

Here’s an example: Jill is responsible for energy management in an injection molding facility.

She tracks electric energy consumption as kWh per completed widget. She has invested in insulation jackets for the old injection molders and installed variable frequency drives on the pump motors to improve efficiency. Two months after the improvements had been installed, her plant manager comes to her to discuss the recent electric bill. He shows her that usage is up 10% over the same period last year and says the improvements must not be working. Jill pulls out her latest graph that shows kWh per completed widget is 25% less than the same period last year, but production is up 46% percent. Through Jill's energy management effort the plant is producing 46% more product with only a 10% increase in electrical energy. Yes, usage is up, but so is production efficiency.

Notice that the preceding example looks at usage, not dollars. If usage is the same and dollars have changed then one of two things have happened, prices charged by the supplier have changed, or the way the energy is used has impacted cost. More about this will be discussed later.

Production of waste also wastes energy. It takes energy to manufacture a bad product. As waste accumulates, begin thinking of it as energy dollars. In the example preceding with Jill, the energy manager, the completed widget unit was a good widget. The kWh per completed good widget will decrease as waste is reduced. Waste comes in many forms other than a bad product. It can be compressed air pressure that is too high, water that is overheated, exhausted heat than can be recovered or simply poor thermostat management.

Key points to remember are:

1. Energy usages interact within a facility - rarely standing alone
2. Energy must be tracked in such a way that allows for variables yet captures efficiency
3. Waste takes many forms.

What Can and Can't Be Controlled

It is important in the world of energy management to understand those things that can be controlled and those that cannot. Any attempt to control the uncontrollable only results in frustration and wasted effort.

Regulated Prices

Regulated tariff prices for utilities are mostly out of the energy manager's control. Other than some input during the rate-making process, the prices are set by the regulatory agencies. The control you do have is in understanding how to use energy most cost-effectively within the tariff. For example, most electric tariffs for larger users have an electrical demand component (kWd) in addition to the energy usage charge (kWh). Depending on the utility, this demand charge may be higher during different seasons or time of day. The goal is to flatten the demand profile or move the higher demands to off-peak times. By doing this, the average cost per unit of electrical energy will decrease. Your utility representative is usually the best source for explaining how to best optimize your usage under your pricing tariff. There are also energy consultants available, but utilities often provide the same service at no cost.

Employees

Employees also have an impact on energy management. Although employees can't be fully controlled, they can be educated and trained on how their actions impact efficiency. An employee needs to be aware of how their daily tasks fit into the overall picture. One plant, as a part of their energy management program, had a goal to improve plant energy efficiency by 10% through employee education. The plant held a one-hour weekly employee training session. During these sessions the employees were taught the big picture of the plant's process, how utility rates work, how their individual tasks fit in and were encouraged to offer suggestions for efficiency improvements. They were also given instruction on how to lower their utility expenses at home. The program was a great success. Never underestimate the impact a concerted effort by employees can have on facility energy efficiency.

Weather

Some facilities are greatly impacted by weather variations. Weather is simply uncontrollable. The most that can be done is to be sure the building is as thermally cost-efficient as possible. Also, some utilities are beginning to offer fixed bills for weather-sensitive loads. These programs are different than equalized billing programs which have a true-up month. The fixed bill programs are contracted usually for a year, and that is what you pay regardless of weather-impacted usage. This is a new concept that has limited availability throughout the country and has a level of risk that some regulators dislike.

The Economy

The general economy of the facilities' business sector is uncontrollable by the energy manager. For example, if demand slumps for the product being produced, then the energy per unit will increase due to the consumption of energy overheads such as lighting and space conditioning. Another example could be a grocery store where sales decrease, but energy is still demanded to keep product cooled.

Design Deficiencies

Another factor that is uncontrollable may be certain inherent design deficiencies. An example would be north-facing doors in a northern climate or extremely low ceilings that prohibit the use of more efficient lighting fixtures.

As you can see, it is important to recognize controllable and uncontrollable items so individual focus can be placed where it will produce the most results.

The Big Three

Next, let's consider the usual big three energy-consuming sectors within industrial and commercial facilities. They are process equipment, lighting, and space conditioning.

Process Equipment

Process equipment is those pieces of equipment used to manufacture a product. Large energy consumption occurs when materials are melted, frozen, formed, separated, joined, or chemically altered. Often just one piece of equipment dominates usage such as one large motor or kiln. This makes it more difficult to make continuous energy improvements. However, the reduction of waste and better quality control always result in energy savings per unit manufactured. In processes that require heat or removal of heat, only heat or cool to the minimum extent required. Where varying centrifugal loads occur on pumps and fans, use variable frequency drives to match input to load. Continuously look for ways to reduce friction, drag, head, and other items that impede product flow or require work. Reducing these items produces a reduction in energy consumption.

Two pieces of process equipment that merit a little more discussion are industrial refrigeration systems and motors. Industrial refrigeration systems can be prime candidates for efficiency improvements. The following are areas to consider that lead to more efficiency:

- Floating head pressure
- Variable frequency drives on evaporative condensers
- Heat recovery
- Central ammonia plant instead of packaged “Freon” systems
- Multi-staging for systems serving different temperature zones

Most industrial processes require the use of motors. Motor efficiency has improved over the years, and premium efficient motors should be considered when their extra cost can be recovered through energy savings. The following table indicates the efficiency level needed for a motor to be classified as premium efficient.

RPM	Totally enclosed fan-cooled and explosion-proof motors premium efficiencies (percent)				Open drip-proof motors premium efficiencies (percent)			
	3600	1800	1200	900	3600	1800	1200	900
HP								
1	78.5	85.5	82.5	77.0	84.0	85.5	82.5	77.0
1.5	85.5	86.5	87.5	80.0	85.5	86.5	86.5	78.5
2	86.5	86.5	88.5	85.5	86.5	86.5	87.5	87.5
3	87.5	89.5	89.5	85.5	86.5	88.5	88.5	88.5
5	89.5	89.5	89.5	87.5	87.5	89.5	89.5	89.5
7.5	91.0	91.7	91.7	88.5	90.2	91.0	91.7	91.0
10	91.7	91.7	91.7	91.0	91.0	91.7	92.4	91.7
15	92.4	93.0	92.4	91.0	91.7	93.0	92.4	91.7
20	92.4	93.0	92.4	91.7	92.4	93.0	93.0	92.4
25	93.0	94.1	93.6	91.7	93.0	93.6	93.6	92.4
30	93.0	94.1	93.6	93.0	93.0	94.1	94.1	93.0
40	93.6	94.5	94.5	93.0	93.6	94.5	94.5	93.0
50	94.1	94.5	94.5	93.6	94.1	94.5	94.5	93.6
60	94.5	95.0	95.0	93.6	94.5	95.0	95.0	94.1
75	94.5	95.4	95.0	94.5	94.5	95.4	95.0	95.0
100	95.0	95.8	95.4	94.5	94.5	95.4	95.4	95.0
125	95.8	95.8	95.4	95.0	95.0	95.8	95.4	95.0
150	95.8	96.2	96.2	95.0	95.0	96.2	95.8	95.0
200	96.2	96.2	96.2	95.4	95.8	96.2	95.8	95.0

Refer to the preceding table for the following example. A plant utilizes an 1800 rpm totally enclosed 150 hp motor to convey raw materials. The motor is operated almost constantly (7200 hours per year). The motor is over 25 years old and is budgeted for replacement. The efficiency is estimated at 90% (table not shown). The minimum efficiency of a new motor is 95% (table not shown), but a premium efficiency motor is 96.2% (see preceding table). Assuming the cost for electric energy is \$8.00 per kilowatt demand (kWd) and \$0.04 per kilowatt-hour energy (kWh) then the annual energy cost calculation is as follows:

$$\text{kWd existing} = 150 \text{ hp} \times 0.746 \text{ kW/hp} \div 0.90 \text{ eff} = 124.3 \text{ kWd}$$

$$\text{kWd existing annual cost} = 124.3 \text{ kWd} \times \$8.00/\text{kWd} \times 12 \text{ months/year} = \$11932.80 \text{ kWh}$$

$$\text{existing} = 124.3 \text{ kWd} \times 7200 \text{ hours} = 894960 \text{ kWh}$$

$$\text{kWh existing annual cost} = 894960 \text{ kWh} \times \$0.04/\text{kWh} = \$35798.40$$

$$\text{Total annual energy cost for existing motor} = \$47731.20$$

$$\text{kWd minimum eff.} = 150 \text{ hp} \times 0.746 \text{ kW/hp} \div 0.95 \text{ eff} = 117.7 \text{ kWd}$$

$$\text{kWd minimum eff. annual cost} = 117.7 \text{ kWd} \times \$8.00/\text{kWd} \times 12 \text{ months/year} = \$11299.20 \text{ kWh}$$

$$\text{minimum eff.} = 124.3 \text{ kWd} \times 7200 \text{ hours} = 847440 \text{ kWh}$$

$$\text{kWh minimum eff. annual cost} = 847440 \text{ kWh} \times \$0.04/\text{kWh} = \$33897.60$$

$$\text{Total annual energy cost for new minimum efficiency motor} = \$45196.80$$

$$\text{kWd premium eff.} = 150 \text{ hp} \times 0.746 \text{ kW/hp} \div 0.962 \text{ eff} = 116.3 \text{ kWd}$$

$$\text{kWd premium eff annual cost} = 116.3 \text{ kWd} \times \$8.00/\text{kWd} \times 12 \text{ months/year} = \$11164.80 \text{ kWh}$$

$$\text{premium eff.} = 116.3 \text{ kWd} \times 7200 \text{ hours} = 837360 \text{ kWh}$$

$$\text{kWh premium eff annual cost} = 837360 \text{ kWh} \times \$0.04/\text{kWh} = \$33494.40$$

Total annual energy cost for new premium efficiency motor = \$44659.20

Note that the above is a simple example and assumes a constant 100% loading and a simple electric tariff. The energy manager must know the nuances of the actual situation and also how to apply the applicable electric tariff. In addition, many factors will need to be considered as to whether to select the minimum efficient motor or the premium efficient motor. Some of those factors will be discussed later in this course.

Lighting Equipment

Lighting is often the largest energy consumer in large office areas, retail stores, and distribution centers. Until recently, the most common lighting source in commercial buildings has been fluorescent lighting fixtures with occasionally some high-intensity discharge (HID) lamps in high ceiling warehouse-type spaces. However, with the advent of cost-effective light-emitting diode (LED) lighting, more facilities are embracing this energy-saving technology and with good reason. Lighting energy efficiency is quantified in lumens (light output) per watt (energy consumed) which is called luminous efficacy. Older lighting technologies have efficacies of approximately 15 for incandescent, 60 for HID, and 87 for T8 fluorescents with numbers varying somewhat. In contrast, LED efficacy can exceed 170 plus which demonstrates their outstanding potential for energy savings.

In addition to energy savings, LEDs offer other benefits such as environmental friendliness, since they are mercury-free and more durable. LEDs are also addressable and can be programmed.

Other aspects at work are directional. This is often critical in such operations to be appropriate for the tasks being performed. Illuminating Engineering Society (IES) which member that reduction in lighting loads also r

Finally, technology LED lighting is a winner with lamp life

Though LEDs respond to improved controls. Control programmable devices have energy through light balanced with art sensors, and available natural

The table below displa

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